*A Dissertation on*

# ELECTROCARDIOGRAPHIC CORRELATION OF ECHOCARDIOGRAPHIC LEFT ATRIAL ENLARGEMENT

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# CERTIFICATE

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# INTRODUCTION

**ECHOCARDIOGRAPHIC CORRELATIONS OF ELECTROCARDIOGRAPHIC LEFT ATRIAL ENLARGEMENT**

It cannot be disputed that the traditional role of the electrocardiogram in the assessment of cardiac dimensions has lost its prominence in favour of imaging techniques that provide a visual multidimensional display of the heart, both in still and motion images.

Predictably, the electrocardiographic examination for the purpose of making an anatomic diagnosis is bound to become superfluous as soon as one or more of the accurate imaging techniques is able to match the electrocardiogram in availability, simplicity of application and cost. However, today the closest challenger, that is, the two dimensional echocardiogram still demands considerably more time, expense, technical skill of the operator and complexity of processing than does the routine 12-lead electrocardiogram. Also, the traditions in Medicine yield slowly, particularly when the new technology introduces unfamiliar displays requiring re-education and calling for abandonment of experiences rooted in familiar associations. For these reasons, the practicing physician of this generation will probably continue to rely on the electrocardiogram as a simple non invasive tool for the initial assessment of gross cardiac anatomy for some time to come.

It may also be anticipated that the correlations with the imaging techniques will improve the performance of the electrocardiogram in the assessment of cardiac anatomy by defining more accurately the limits of its capability.

The purpose of this study is to outline the status of electrocardiography in the diagnosis of left atrial enlargement in the era of new diagnostic techniques.

# AIM OF THE STUDY

This study was designed to assess the sensitivity and specificity of selected electrocardiographic signs of left atrial enlargement using echocardiographic left atrial dimension as the diagnostic standard.

To determine the predictive values of the selected electrocardiographic signs of left atrial enlargement.

# REVIEW OF LITERATURE

## ANATOMY

Left atrium is a quandrangular chamber situated posteriorly and forms two thirds of the base of the heart. Left atrium develops mostly from the absorbed proximal portion of PV. The other structures from which it develops are left half of primitive atrial chamber and left half of AV canal. Atrial septal wall on left side has fossa lanata corresponding to the fossa ovalis of Right atrium. Left atrium is supplied the LCA. The atrial muscle fibres are arranged in a longitudinal direction, has synctial structures like ventricle and self excitatory potential at a rate of 35/mt. Lt atrium receives oxygenated blood from the lung through pulmonary vein, passes it to the LV through the mitral valve. 10% of the blood entering the Lt atrium flows directly into the ventricle before atrial contraction occurs. The atrial contraction causes only additional 30% of ventricular filling. The normal resting heart maintain the cardiac output satisfactorily without the extra 30% filling of ventricle by left atrial systole. Left atrial pressure raises to 7 - 8 mm Hg, during contraction. Normal left atrial diameter is less than 39mm.

**PATHO PHYSIOLOGY**

Left atrial enlargement occurs in rheumatic heart disease – very commonly. The valvular involvement are mitral stenosis, mitral regurgitation , aortic stenosis, aortic regurgitation and with various combination. Patients with pure mitral stenosis and mitral stenosis with aortic regurgitation do not differ in hemodynamic, clinical or ECG measures.

Left atrial pressure varies between 8–32 mm Hg. Normal mitral valve orifice is 4 – 6 $cm^2$, when the orifice is reduced to $2cms^2$, it is called as mild mitral stenosis. When the mitral valve orifice is less than $1cm^2$, it is called as critical mitral stenosis. Both conditions produce increased outflow resistance at the mitral valve and left atrial pressure raises to 25mm Hg to maintain cardiac output at rest.

Left atrial enlargement in mitral stenosis show 'P' terminal force more than 0.04 msec in lead$V_1$ and prolonged p wave duration in Lead II. In acute mitral regurgitation, there is little enlargement of left atrium and marked elevation of left atrial pressure. But after few weeks to months, Left atrial wall undergoes hypertrophic changes. Severe long standing MR is associated with massively enlarged left atrium and with normal or slightly elevated left atrial pressure.

Atrial wall contains small amount of muscle and great deal of fibrous tissue. These patients invariably have atrial fibrillation patients with severe

MR have abnormal ‘P’ terminal force in lead $V_1$. In AS and AR when severe with LV dysfunction, the left atrial pressure is elevated and mild Left atrial enlargement may be seen. In combined MS and MR, left atrial pressure varies from 8 – 32 mm Hg. ECG abnormalities of increased ‘P’ wave duration, abnormal ‘P’ terminal force in $V_1$, and P/Pr segment ratio is increased.

Hypertensive patients with systolic blood pressure of 140mm Hg or higher were twice likely to have left atrial enlargement. This was proved in Framingham heart study of influence of blood pressure on heart size. Increased left atrial size has been identified as a precursor of atrial fibrillation and of stroke. The left ventricular hypertrophy correlates with left atrial size.

## ISCHEMIC HEART DISEASE

In patients with CAHD, LV dysfunction (EF < 40%) and increased LVEDP occur. In 70% of such cases, they are associated with Left atrial enlargement. In acute myocardial infarction, ‘P’ terminal force of ECG determines LV dysfunction.

## CONSTRICTIVE PERICARDITIS

Significant left atrial dilatation occurs in constrictive pericarditis with regression after successful pericardiectomy. (Engle et al). Reviewed M – mode echocardiogram from 40 patients with proven constrictive pericarditis show left atrial enlargement.

## CARDIOMYOPATHY

Dilated cardiomyopathy is associated with increased left atrial size and reduced left atrial contractile performance. Hypertrophic obstructive cardiomyopathy is also associated with increased left atrial size.

Rare congenital anomaly like aneurysm of left atrium and left atrial appendage has increased left atrial size. They are best diagnosed by trans oesophageal echo cardiography. This aneurysm may also be due to acquired causes, following atrial MI. It forms bulging of left heart border on chest X-ray and is associated with atrial fibrillation. This may be the possible source of thrombosis. Atrial fibrillation disappears following surgical excision of aneurysm. Other conditions associated with increased left atrial size include atrial septal defect, ventricular septal defect, left atrial myxoma, ebstein's anomaly, mitral valve prolapse.

The ECG is a graphic recording of electric potentials generated by the heart. .The signals are detected by conventional 12- Lead metal electrodes attached to limb extremities and chest.

They are

1. Standard limb leads (Lead 1-3)

2. Unipolar augmented limb leads (AVR, AVL, AVF) 3. Precordial Chest leads (V1-V6)

When the conventional methods fail to get information, certain special electrodes can be used. They are

1. OESOPHAGEAL LEADS AND

2. ATRIAL LEADS

OESOPHAGEAL LEADS are useful in the diagnosis of atrial activity, its arrythmias because large atrial deflection may be recorded in this lead. Oesophageal leads are placed at two levels.

1. Ventricular Levels-50-60 from external nares, produce upright P wave.

2. Atrial levels –lead is located at a distance of 25-40 from external nares, record biphasic P wave with initial positive and final negative wave QR with T wave inversion. Oesophageal leads are designated by the letter E . So in E -50, 50 denotes the distance from nares.

ATRIAL LEAD-It records the atrial activity more clearly than conventional leads. Atrial leads are used when conventional electrocardiography is not showing atrial activity. Atrial leads are preferable to oesophageal leads because of their simplicity and minimal discomfort to the patient. Leads at high atrial level record negative P wave, mid atrium records biphasic P waves, low atrium produce upright P waves. Atrial leads are useful in the differentiation of supra ventricular arrhythmias and ventricular arrhythmias. Generally Electrocardiography is used for detecting chamber hypertrophy, arrhythmias, ischaemia, infarction, electrolyte abnormalities, and conduction disturbances. Usually left atrial enlargement is noted in the lead-II Standard lead because frontal plane P wave axis is usually directed to the positive pole of this lead. P wave in lead II is pyramidal in shape with a rounded apex. Duration is 0.08-0.1 sec, maximum amplitude is 2.5 mm. P wave morphology in lead V 1 is diphasic with initial positive deflection followed by terminal shallow negative deflection in that lead. Terminal deflection does not exceed 1 mm depth and 0.03 sec in duration. Normal frontal plane P wave axis is directed to a region of + 45 degree - + 65 degree.

There are a variety of reasons when ECG may not reflect accurately the electrical activity of the heart. With the exception of arrhythmias, no single electrocardiographic sign in the ECG is diagnostic of any disorder.

The ECG criteria used for a variety of diseases were derived from correlating clinical, anatomical, pathological and physiological studies. Even at the present state of knowledge the ECG diagnosis is based on empirical evidence to identify a variety of anatomic, metabolic, neural and haemodynamic changes. Inspite of these limitations, the ECG is a very useful investigation. It is the only practical method of recording the electrical activity of the heart. Since the main function of the heart is pumping blood for the needs of tissue and not generation of electricity, it is not surprising that THE ECG IS NORMAL WHEN THE HEART IS ABNORMAL, AND IT IS ABNORMAL WHEN THE HEART IS NORMAL.

The electrocardiographic patterns often attributed to left atrial enlargement may evolve from Left atrial pressure over load but also caused by dilation of left atrial chamber, thickening or impaired atrial conduction. Previous studies exploring the accuracy of various electrocardiographic criteria for left atrial enlargement used populations that were small or lacking in appropriately matched controls. These studies focused on 1,2 or at the most 3 electrocardiographic criteria and many used diagnostic standards of left atrial enlargement that were of uncertain accuracy (radiagraphic studies and post mortem examination). Echocardiography now provides a simple non invasive reproducible means of assessing left atrial size.

For this reason, recent studies evaluating electrocardiographic criteria for left atrial enlargement have used echocardiographic left atrial dimension as their diagnostic standard.

The detection of left atrial enlargement or its progression is frequently important in clinical medicine. The techniques traditionally used to evaluate left atrial size have been x-ray examination of the Barium filled oesophagus, angiocardiography, electrocardiography and echocardiography. All these techniques have drawbacks.

Angiography an invasive procedure requires cardiac catheterization, and cannot be regarded as a routine test. Barium studies entail a great deal of Co-operation from the patient, require extensive radiological facilities and because of the radiation hazard, they cannot be performed on pregnant women and cannot be repeated frequently.

Also Barium studies can detect only severe grades of left atrial enlargement. With lesser grades and with concomitant left ventricular enlargement, false negatives are more frequent. Hence, there is a need for a simple, non-injurious and frequently repeatable technique for reliably assessing left atrial size.

The choice currently lies between the electrocardiogram and the echocardiogram. Many criteria have been proposed for the electrocardiographic recognition of left atrial enlargement and all are based on the p wave. They include the classic ‘P MITRALE”. (Lewis 1920 : Berlines and Master 1938), the ratio of duration of the p wave to the duration of the PR segment also called the Macruz index (Macruz, Perloff and Lase 1958) and the P terminal force, which is the product of the p wave duration (in sec) and its depth (in mm) in lead $V_1$.

The p terminal force is generally regarded as the best electrocardiographic criterion for detecting left atrial enlargement (Morris et al 1964; Hurst et al 1963, Soloff and Zatuchini 1958).

The electrocardiographic diagnosis of left atrial enlargement suffers from a variety of limitations. These include the technical problems of recording and accurately measuring very small deflections, the inability to distinguish between pressure overload and true anatomical enlargement. (Pipeberger and Tanen Baum 1958, Kasser and Kennedy, 1969). The loss of the p wave from atrial fibrillation makes ECG detection of left atrial enlargement impossible. Despite these limitations the ECG is widely used to assess left atrial size in clinical medicine. (Arevalo, Spagnulo and Feinstein 1963; Ishikawas, Kini and Piperger 1973 and Shyman 1963). The recent technique of echocardiography also enables left atrial size to be measured (Fiegenbaum 1972 and Hirata et al. 1969). Since this is a non invasive, non radiological technique, it is comparable to the ECG in its safety and ease of performance.

In contrast to the ECG, left atrial dimension as measured by echocardiogram is uninfluenced by acute rise in left atrial pressure (Chandraratnanada and Shah 1976).

While echo measurements of left atrial size have been shown to correlate well with left atrial volumes determined by angiography (Hirata et al. Jeu Cate et al. 1974), there is little information on how reliable each technique is in detecting left atrial enlargement in purely clinical situation.

Left atrial enlargement can be suspected in an electrocardiogram when a wide p wave is recorded due to posteriorly directed terminal p wave component of increased duration. The wide separation between the anteriorly and posteriorly directly p wave components results in a prolonged interval between the peak of the initial upright portion and the nadir of the following inverted p wave portion of the right precordial leads. Such p waves are usually upright and notched in leads I, II and $V_4$ to $V_6$ and either positive – negative or negative in leads III and aVF. Because the pattern associated with left atrial enlargement indicates and intra-atrial conduction disturbance. Rather than hypertrophy or dilatation, the preferred term is left atrial abnormality rather than enlargement. This abnormality is usually characterized by increased duration of the p wave, increased ratio of the p wave duration to the duration of the PR segment and increased product of the amplitude of the terminal negative deflection in lead $V_1$.

**AUTOPSY CORRELATIONS**

In the study of Mazzoleni et al increased weight of the left atrium correlated poorly with p wave abnormalities. In the study of Romhit et al. a p wave abnormality in lead $V_1$ was present in 44.3% of hearts with left atrial hypertrophy, 34% of hearts with right atrial hypertrophy, 22.4% of hearts without atrial hypertrophy, 44.4% of hearts with left ventricular hypertrophy, 34.7% of heart with right ventricular hypertrophy and 11.55 of heart without any atrial or ventricular hypertrophy. Although the left atrial abnormality in the electrocardiogram would have correctly predicated a normal or hypertrophies atrium in only 66.7% of cases, the finding had high specificity for heart disease because it occurred only in 3.8% of patients who had no evidence of either atrial or ventricular hypertrophy.

**CLINICAL AND HEMODYNAMIC CORRELATIONS**

The electrocardiographic pattern of left atrial abnormality is present frequently in patients with hypertension and sometimes represents the only electrocardiographic abnormality in this condition. The pattern may appear transiently in patients with pulmonary oedema. In some patients with acute myocardial infarction and congestive heart failure, the p wave abnormality in $V_1$ correlated significantly with increased pulmonary capillary wedge pressure, but in others, the presence or absence of abnormal p waves was not helpful in assessing the pulmonary capillary wedge pressure before or during treatment of congestive heart failure. It has been shown that a p wave abnormality in lead $V_1$ which meets the criteria of Morris et al for left atrial enlargement, is frequently present in patients with corpulmonale, in the absence of left atrial enlargement.

## ECHOCARDIOGRAPHIC EVALUATION OF LEFT ATRIUM

### TWO – DIMENSIONAL EXAMINATION

Two – dimensional studies of the left atrium can be obtained with the transducer in almost any portion on the chest. This chamber is commonly visualized with the transducer placed along the left sternal border (parasternal), at the apex, or in the subcostal position. Although the suprasternal two – dimensional study has principally been used to examine the aorta and pulmonary artery, it is also possible to obtain a two – dimensional view of the left atrium from this approach.

The left atrium may also be recorded in the two apical views. Occasionally it is possible to see the pulmonary veins entering the left atrium in the apical four – chamber view. The subcostal examination provides another way of visualizing the left atrial chamber.

It is thus possible to examine the left atrium from multiple directions. Fortunately, since the left atrium is basically spherical, any one of these examinations is usually sufficient. In the few situations where the left atrium does not assume a spherical configuration, more than one view is necessary to appreciate the status of this chamber. The dilated chamber becomes even more spherical than normal, and both the long-axis and short-axis views are circular. In the long-axis view, the aorta is displaced anteriorly and the posterior left atrial wall is displaced posteriorly. In the short-axis view, the inter atrial septum is displaced to the right.

A potential problem that has arisen with regard to judging the left atrium with two – dimensional echocardiography is that of side lobes. A frequent location for side lobe production is the posterior atrioventricular groove. A band of curved, bright echoes may originates from that area of the heart. With a normal – sized left atrium, the band of echoes occur at the level of the posterior left atrial wall and is usually obscured by echoes posterior to the left atrium. However, if the left atrium is enlarged, the posterior displacement of the atrial wall permits visualization of the side lobe echoes within the cavity of the left atrium. Fortunately if one recognized the side lobes, the angle of the transducer can be changed slightly to eliminate or diminish the side lobes.

The left atrium is at its largest at the end-systole immediately before the mitral valve opens and attains its smallest volume at end – diastole following atrial systole.

## LEFT ATRIAL VOLUMES

Several efforts have been made to use two – dimensional echocardiography to measure left atrial volumes. The views that have been used include the parasternal long-axis, parasternal short-axis, apical four – chamber, and apical two – chamber examinations. The area, length, and minor dimension have been measured in each of these views. A combination of two of the three views is commonly suggested. A biplane area length formula has been proposed. For example, one technique for measuring left atrial volume involves obtaining the area and length in the four and two-chamber views.

The formula is $$v = \frac{8 \times A_1 \times A_2}{3n \times L}$$

Where A1 = the area of the four-chamber view

A2 = the area of the two – chamber view, and

L = the common length in the two views.

Another group of investigators used the volume formula

$$V = D^2 \times L \times n \times 6$$

Where D = the minor axis and

L = the major axis in any given view

Left atrial volume can also be calculated using an ellipsoid model using the formula.

$$V = \frac{4n}{3} \times \frac{L}{2} \times \frac{D1}{2} \times \frac{D2}{2}$$

Where L = Superior inferior dimension in apical 4 – chamber view.

$D_1$ = Antero posterior dimension in parasternal long axis view.

$D_2$ = Medio lateral dimension in parasternal short axis view.

- In all these techniques, the atrial appendage and pulmonary veins were excluded from the measurements.
- For a single measurement, the left atrial volume was usually obtained in systole when the chamber had its largest volume.

As in the case with right ventricular volumes, there is no generally accepted echocardiographic technique for measuring left atrial volumes. The M-mode measurement between the anterior and posterior walls of the left atrium at end – systole has been utilized for many years. Although the relationship between this measurement and the volume is not perfect, this simple dimension has provided a clinically useful estimate of left atrial size. One can certainly use a similar measurement utilizing two – dimensional echocardiography. Thus, one could be justified in merely measuring between the anterior and posterior left atrial walls in the parasternal long – axis view to reflect the comparable M – mode dimension that has been used for many years. As with all simple measurements, limitations are many. Although the left atrium has been assumed to enlarge as a sphere, it is obvious that symmetrical enlargement does not always occur. In addition, dilatation of the aorta, which is anterior to anterior wall of the left atrium markedly distorts any anterior posterior dimension. Encroachment on the left atrium form enlarged posterior structures can also alter the left atrial dimensions.

Fortunately, the qualitative two – dimensional examination readily recognizes when asymmetric dilatation or gross distortion of the left atrium occurs. Under these circumstances, one can modify any assessment of left atrial size using the simple anterior – posterior measurement.

**EXAMINING PLANES AND LINEAR DIMENSION**

The left atrium is imaged using the parasternal long axis, short axis, and apical four – chamber views. Because of its spherical or ovoid shape, the left atrium has no natural long or short axis. The axes of the left atrium, therefore, are defined echocardiographically relative to those of major adjacent structures. Thus, the echocardiographic long axis of the left atrium lies in the same plane and is roughly parallel to the long axes of the aorta and the left ventricle. Likewise, the short axis of this chamber corresponds to the short axes of these adjacent structures.

In the parasternal long axis view of the left atrium, the plane passes through the atrium in anteroposterior direction. Two linear dimensions can be derived from this view, i.e., the anteroposterior dimension, taken as the distance between the posterior root of the aorta and the posterior left atrial wall at the level of the aortic value, and the superior – inferior dimension, measured from the superior atrial wall to the plane of the mitral annulus through a point that roughly bisects the antero posterior dimension.

In the parasternal short axis view of the left atrium, the imaging plane passes through this chamber from the anterior to the posterior borders. Two linear dimensions can be derived from this plane, i.e., anteroposterior dimension, taken as the length of a line drawn from the midportion of the posterior aortic root anteriorly to the posterior atrial wall, a medial lateral dimension, which is the distance between the endocardial intercepts of a line that is perpendicular to and bisects the anteroposterior dimension.

The apical four – chamber view transects the left atrium from the mitral annulus to its superior wall. The linear dimensions derived from this plane are a superior inferior dimension taken from the midpoint of the mitral annular plane to the centre of the superior atrial wall, and the medial lateral dimension, taken as the length of a line from the interatrial septum to the free lateral wall that bisects the superior inferior dimension.

**M-MODE EXAMINATION**

The M-mode echocardiographic examination permits one to obtain an anterior – posterior dimension of the left atrium. The measurement is taken in the vicinity of the aortic valves and is obtained at the maximum upward motion of the aortic wall, which represents end – systole. According to ASE criteria, the left atrial dimension should be taken from the leading edge of the posterior aortic wall to the leading edge of the posterior left atrial wall.

It is not always easy to clearly identify the posterior left atrial wall to make the proper left atrial dimension. Sometimes anterior to the posterior left atrial walls are multiple echoes, many of which are relatively indistinct. The origin of these echoes is still not determined. Occurring most often with dilated left atria in patients with mitral stenosis, they may originate from relatively stagnant blood layered against the left atrial wall. An alternate explanation may be artifact, partially owing to side lobes. In any case, the correct left atrial dimension is usually more posterior than is the band of indistinct echoes.

The location in the cardiac cycle from which the left atrial dimension is taken has customarily been at end - systole where the maximum left atrial dimension occurs. This technique was first utilized because of this measurement provided the largest left atrial dimension and because the upward motion of the posterior aortic wall was convenient for measurement. Although other areas of the cardiac cycle have been recommended for left atrial dimensions, the end – systolic locations continues to be most often used and is recommended by the society.

Another way of assessing left atrial size is to compare the left atrial dimension with the diameter of the aorta. In the normal patient the diameter of the aorta and that of the left atrium are about equal. As the left atrium dilates, this relationship changes with the left atrial dimension becoming significantly larger than that of the aorta. Many articles in the literature correlate echocardiography and angiography for judging the size of the left atrium. The correlations have been extremely good with almost all having approximate R values of 0.9. The M-Mode left atrial dimension is clearly better than merely looking at the plain chest roentgenogram for judging left atrial enlargement. Although the technique originally recommended correcting the dimension for body surface area, it is debatable whether the body surface area is infact useful in comparing one individual with another. As expected, Aorta – left atrium ratio is used rather extensively in pediatric echocardiography. Other authors believe that merely taking the uncorrected left atrial dimension and comparing to known normal values is the best way of judging whether the chamber is dilated.

Irrespective of exactly how the left atrium is measured, this echocardiographic dimension has proved useful. The size of the left atrium is important in patients with mitral valve disease or chronic left ventricular failure. One study shows the relationship between the echocardiographic measurement of the left atrium and the presence of atrial fibrillation. Another important clinical use of the echocardiographic left atrial measurement is in infants with left – to – right shunts, such as patent ductus anteriosus or ventricular septal defect. These infants may manifest heart failure or respiratory distress, and the mere finding of a dilated left atrium may be extremely important to establish the diagnosis. In addition, the size of the left atrium gives semiquantitative information as to the size of the shunt.

The left atrium may also be examined with the transducer placed in the suprasternal notch pointed inferiorly and slightly to the left. With the transducer in this position, the ultrasonic beam passes through the arch of the aorta, the right pulmonary artery, and the left atrium. Although this approach has had relatively little use in examining the left atrium in selected patients, this left atrial dimension may be a useful supplement to the standard measurement taken from the left sternal border. The left atrial measurement is slightly larger with the suprasternal approach, but the measurements are otherwise comparable. In a patient with severe pectus excavatum, there may be considerable difference in the left atrial dimension depending on the orientation of the ultrasonic beam. Because of the chest deformity, a much smaller left atrial dimension may occur in the parasternal approach than in the suprasternal technique.

## LEFT ATRIAL WALL MOTION

Left atrial wall motion is not usually appreciated during the typical left atrial examination at the base of the heart. Although little has been written about left atrial wall motion, this motion occasionally provides some useful information. First, the pattern of the left atrial wall pulsations must be distinguished from that of ventricular pulsations. This distinction is easily made because the two structures move in opposite directions during ventricular systole.

When the ultrasonic beam transects the aorta and aortic valve, the posterior left atrial wall motion is normally negligible. There is virtually no significant posterior left atrial wall motion, even with a dilated chamber. Occasionally, one sees significant pulsations of the posterior left atrial wall in patients with mitral regurgitation. When present at this level, the systolic expansion of the posterior left atrial wall is indicative of mitral regurgitation. Unfortunately, most patients with regurgitation do not demonstrate such systolic expansion.

Patients with mitral regurgitation may have increased motion at the atrioventricular junction. Such motion may again be indicative of increased left atrial stroke volume secondary to mitral regurgitation. However, caution must be observed in judging motion of the atrioventricular junction on the M-mode echocardiogram. The motion seen on the M-mode echocardiogram may be interpreted as anterior – posterior motion of the left atrial wall when infact one is merely recording different areas of the heart during the cardiac cycle. During systole, the atrioventricular junction moves towards the apex of the heart, and the ultrasonic beam may be transecting the left atrium. With diastole, the atrioventricular junction moves towards the base of the heart, and the stationary ultrasonic beam now transects the left ventricle. Thus, at the anterior ventricular junction, one may be recording the left ventricle during diastole and the left atrium during systole.

Numerous reports indicate that if changes in left atrial volume are to be recorded, then the motion of the posterior or wall of the aorta, which is the same as that of the anterior wall of the left atrium, should be scrutinized. The posterior aortic wall has been used to judge both absolute and relative changes in left atrial volume.

## NORMAL CHANGES IN ATRIAL DIMENSIONS DURING GROWTH AND DEVELOPMENT

By birth, the measured dimensions of the left atrium have reached almost 50% of their adult value. This increases to almost 65% by 12 to 18 months of age. Subsequently, the growth rate slows so that by 5 years these dimensions have attained 75% of the adult value. By the time of puberty (12 to 15 years of age), this increases to 90%. Beyond this point, the rate of cardiac growth slows even further, and significant increase in dimensions are not seen after 15 years of age.

Univariate analysis predicts a strong correlation between the antero – posterior atrial dimension and height, weight, body surface area, and age. However, although the relationships between atrial dimensions and both weight and body surface area are nonlinear and predicted by a quadratic equation, the relationship between height and left atrial dimension is linear.

Left atrial antero-posterior dimension = 0.014 x height + 0.69. The above relationship is hence more easily determined and not affected by fluctuations in an individual's weight.

**ECHOCARDIOGRAPHIC CORRELATIONS OF ELECTROCARDIOGRAPHIC LEFTATRIAL ENLARGEMENT**

In two early studies of 36 and 48 patients good correlation was found between p wave abnormalities and left atrial size. In one of these p wave duration greater than 105 MS identified all patients with left atrial dimension of greater than 3.8cm and had a specificity of 89%.

P wave duration was more sensitive and specific than the abnormal p wave in lead $V_1$ (sensitivity and specificity of 75% and 83% respectively). However, in another study[13] the p wave in lead $V_1$ was most useful in estimating left atrial size.

The reports of good correlation between the electrocardiagram and echocardiogram are outweighed by studies showing lack of good correlation between left atrial dimension and either p wave duration or configuration in lead $V_1$. In the study of Josephson et al only 57% of 21 patients with the electrocardiographic pattern of left atrial abnormality had increased left atrial dimension in the echocardiogram, and only 65% of 40 consecutive patients with increased left atrial dimension in the echocardiogram had p wave abnormalities.

In 30 patients studied by waggoner et al the combination of several electrocardiographic criteria had a predictive index of 63% for the presence and 78% for the absence of left atrial enlargement. In 361 patients studied by Miller et al the product of the amplitude and duration of the terminal p wave component in lead $V_1$ had a sensitivity of 51.25% at a product greater than 0.4, 37.8% at a product greater than 0.6 and 20% at a product greater than 0.8.

The declining sensitivity was accompanied by an increasing specificity of 69.9, 85.7, 91.8 and 92.8%. respectively. The authors concluded that a product greater than 0.6 was the most accurate predictor of left atrial enlargement (diameter more than 4cm) in patients with both high and low prevalence of this abnormality.

The echocardiogram was superior to the electrocardiogram in detecting milder degrees of left atrial enlargement and the long-term followup of left atrial enlargement. Echocardiographic correlations also suggest that the high gain vector cardiogram may be superior to the electrocardiogram in the detection of left atrial abnormality. In one study only 40% of 43 patients with a left atrial dimension greater than 4.0cms had signs of left atrial abnormality in the scalar electrocardiogram but 70% had an abnormal ratio of maximal posterior to anterior p wave vector amplitude.

In children with echocardiographically documented left atrial enlargement the electrocardiogram suggested left atrial enlargement in only 50% of patients and the vector cardiogram was even less sensitive that the electrocardiogram. In another study, of 90 children with diseases known to affect the left atrium, the electrocardiogram had a 40% sensitivity and the electrocardiographic and echocardiographic findings failed to agree with each other in 62% of patients.

# MATERIALS AND METHODS

## METHODS

Patients attending the medicine OP, Hypertension clinic and Cardiology OP and suffering from rheumatic heart disease and in sinus rhythm were selected and reviewed specifically for information pertaining to age, sex, type of underlying cardiovascular disease and drug therapy. These patients were then subjected to electrocardiographic and echocardiographic tests.

In selecting patients with a normal echocardiographic left atrial dimension an attempt was made to provide a matched population for the group with enlarged left atrial dimension with regard to age, sex, type of underlying cardiovascular disease and drug therapy that might affect the P-R interval.

Patients were divided into two groups. Those with an enlarged left atrial dimension (more than 40 mm) and those with a normal atrial dimension (less than 40 mm).

## PROTOCOL

M-mode echocardiography was performed using VINGMED CFM 725 ULTRASOUND SYSTEM with a 2.5 MHz TRANSDUCER. Echocardiograms were obtained from an echocardiographic window located in the third or fourth intercostal space at the left sternal border with the patient in the left semi recumbent position.

Measurements of the left atrial dimension were made at end systole, in accordance with the recommendations of the American society of echocardiography. M-mode echocardiographic correlation for left atrial enlargement consisted of left atrial dimension more than 40 mm.

Standard twelve lead electrocardiograms were performed in all patients with BPL India-CARDART 108 electrocardiograph. A magnifying lens was used to better discern ‘p’ wave morphologic characteristics, p wave duration and P-R segment duration. The electrocardiographic criteria used in this study are described in TABLE 1.

## TABLE 1

## ELECTROCARDIOGRAPHIC CRITERIA FOR LEFT ATRIAL ENLARGEMENT

| | |
|---|---|
| 1. | p Terminal force in lead V1 more negative than -0.04mmsec. |
| 2. | Duration of the negative phase of the p wave in lead V1 more than 40 ms. |
| 3. | Depth of the negative phase of the p wave in lead V1 more than 1mm |
| 4. | Total p wave duration more than 110 ms |
| 5. | Notched P wave in any standard lead with an inter peak duration more than 40 ms-p mitrale. |
| 6. | Total P wave duration/ P/R segment duration more than 1.6 – Macruz index |

* PTF = Duration x Depth of the terminal phase of the p wave in lead $V_1$.

**ECHO – CRITERIA OF LEFT ATRIAL ENLARGEMENT**

1. Transverse diameter of Left atrium more than 40 mm

2. Ratio of transverse diameter of Left atrium to transverse diameter of aortic root greater than 1.17.

3. Ratio of left atrial diameter to body surface area above $2.2 m^2$.

**THE RADIOLOGICAL CRITERIA FOR LEFT ATRIAL ENLARGEMENT**

1. Bulge beneath the pulmonary artery.
2. Double density along the right atrial border
3. Elevation of left main bronchus.
4. Left atrial enlargement with barium swallow picture.

# RESULTS

## PATIENT CHARACTERISTICS

The study population consisted of sixty patients in normal sinus rhythm.

Forty five patients had an enlarged left atrial dimension, fifteen patients had normal left atrial dimension.

The study population consisted of 34 men and 26 women.

**Analysis of individual electrocardiographic criteria**

## SENSITIVITY AND SPECIFICITY

## SENSITIVITY

The term sensitivity was introduced by Yerushalmy in 1940s as a statistical index of diagnostic accuracy. It has been defined as the ability of a test to identify correctly all those who have the disease, that is “true positive”.

A 90% sensitivity means that 90% of the diseased people screened by the test will give a “true positive” result and the remaining 10% a “false negative” result.

**SPECIFICITY**

It is defined as the ability of a test to identify correctly those who do not have the disease, that is “true negatives”. A 90% specificity means that 90% of the non-diseased persons will give “true negative” result, and 10% of non-diseased people screened by the test will be wrongly classified as “diseased”, when they are not.

**FALSE POSITIVES AND NEGATIVES**

The term “false positive” means that patients who do not have the disease are told that they have it. In this case, normal healthy people may be subjected to further diagnostic tests, at some inconvenience, discomfort, anxiety and expense – until their freedom from disease is established.

A screening test with a high specificity will have few “false positives”. False positives not only burden the diagnostic abilities, but they also bring discredit to screening programmes.

The term “false-negative” means that patients who actually have the disease are told that they do not have the disease. It amounts to giving them a “false reassurance”.

The patient with a “false negative” test result might ignore the development of signs and symptoms and may postpone the treatment. This could be detrimental if the disease in question is a serious one and the screening test is unlikely to be repeated within a short period of time.

A screening test which is very sensitive has few “false negatives”. The lower the sensitivity, the larger will be the number of “false negatives”.

In fact, no screening test is perfect, i.e, 100% sensitive and 100% specific.

The true positive, true negative, false positive and false negative values of the six electrocardiographic criteria under study are tabulated in table II.

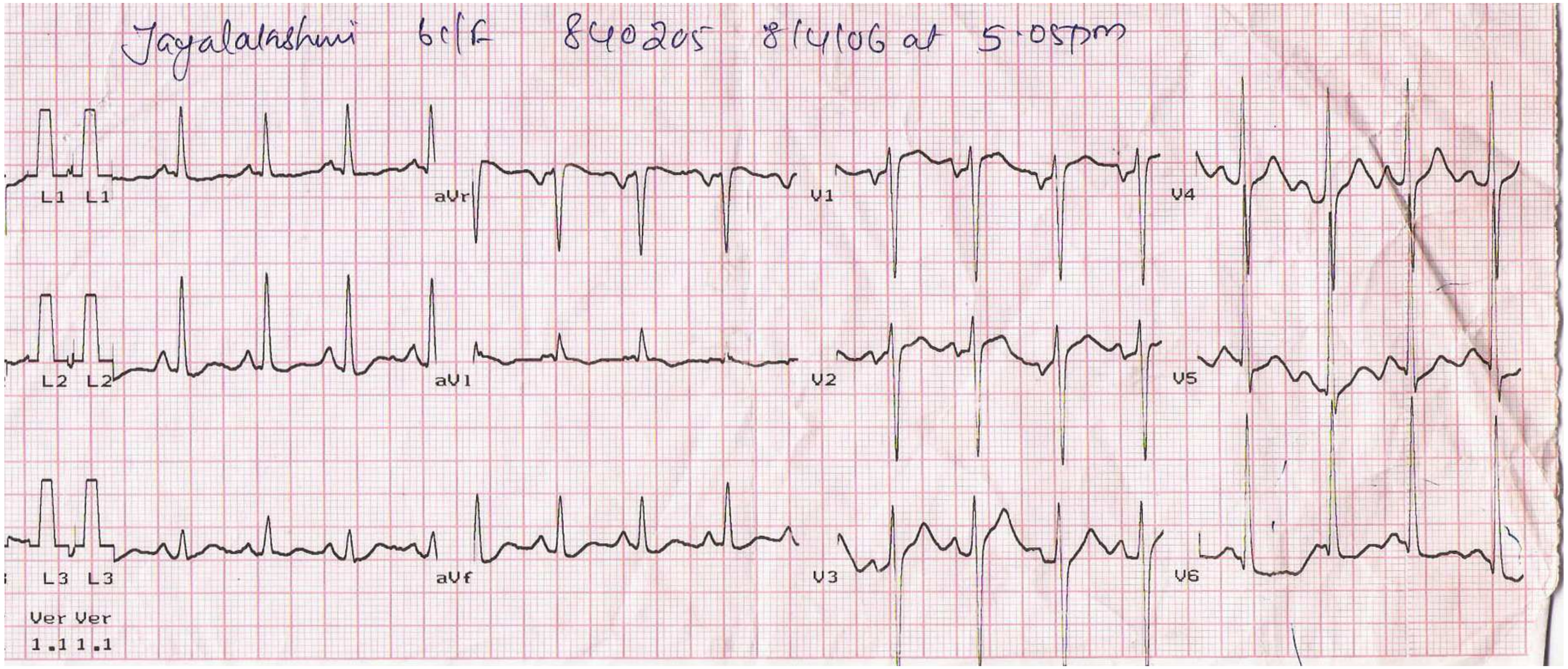



**Fig. 1**

**ECG SHOWING LEFT ATRIAL ENLARGEMENT**

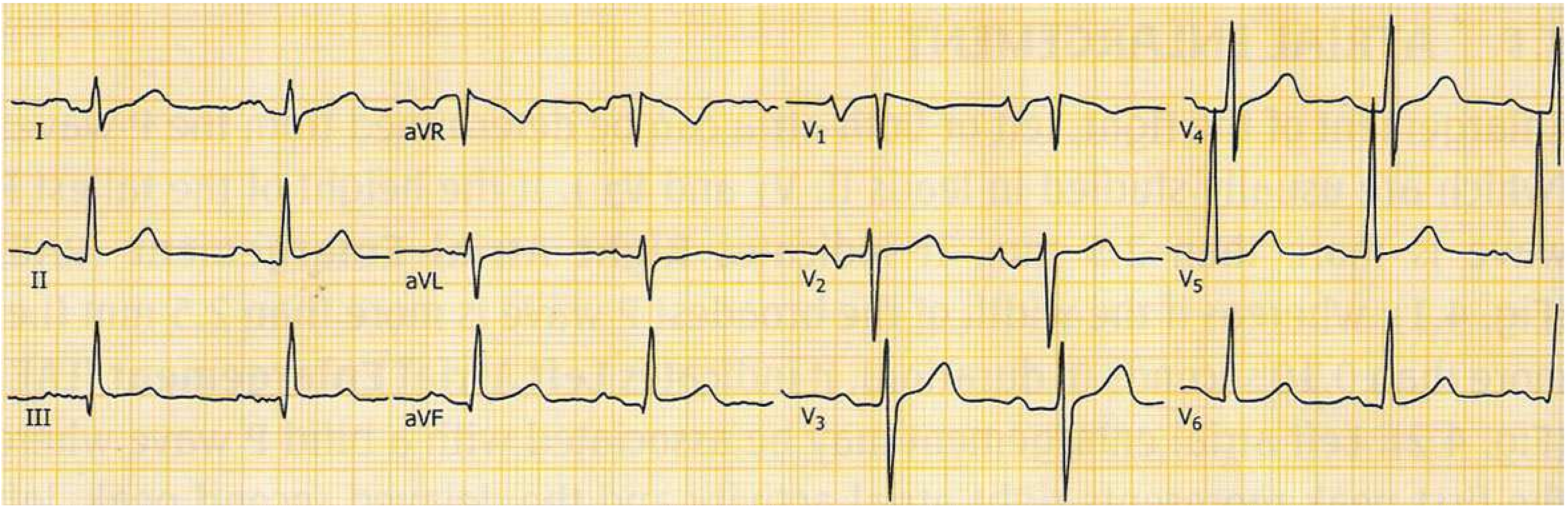



**Fig. 2**

**ECG SHOWING LEFT ATRIAL ENLARGEMENT**

**Fig.1, 2, 3 - Echo Cardiogram showing Left atrial enlargement**

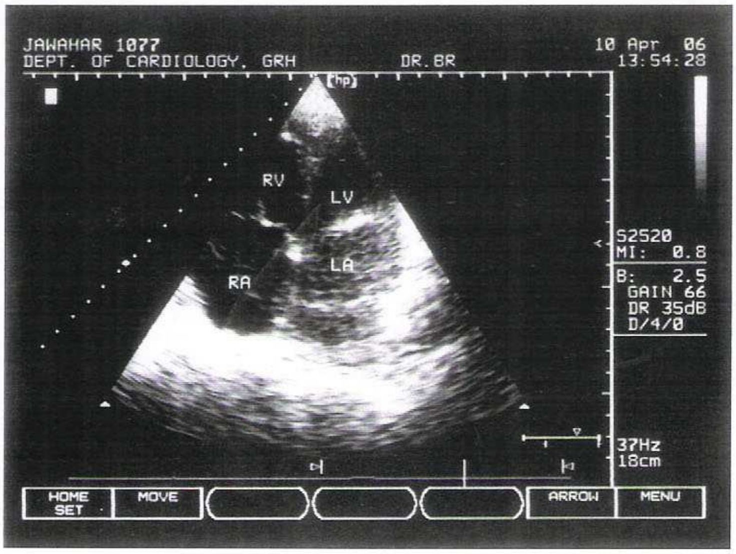



Fig. 1

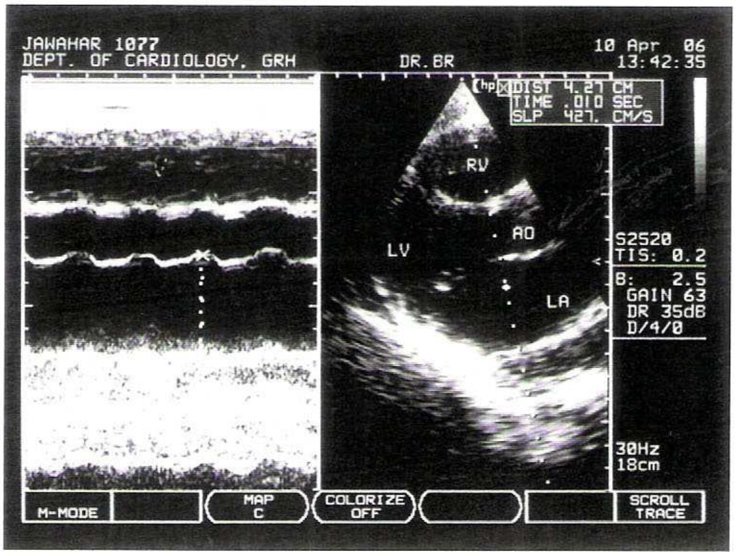



Fig.2

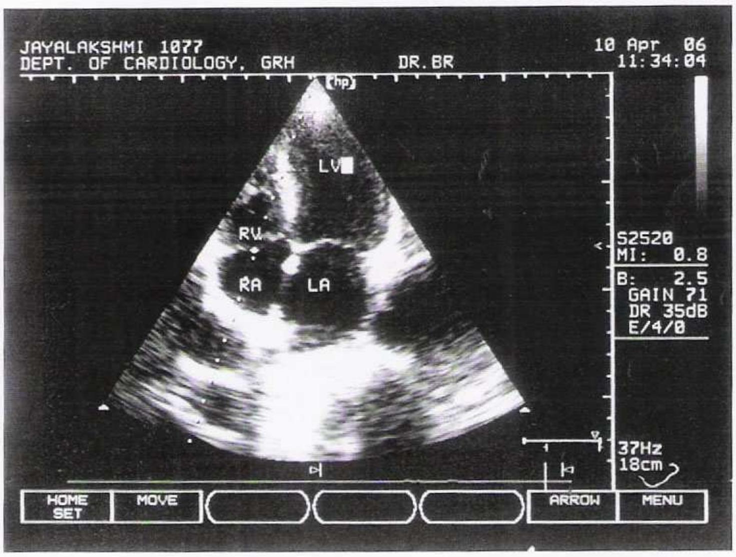

JAYALAKSHMI 1077
DEPT. OF CARDIOLOGY, GRH
DR.BR
10 Apr 06
11:34:04
LV
RV
RA
LA
S2520
MI: 0.8
B: 2.5
GAIN 71
DR 35dB
E/4/0
37Hz
18cm
HOME SET
MOVE
ARROW
MENU

**Fig.3**

## TABLE II

## * TRUE POSITIVE, TRUE NEGATIVE, FALSE POSITIVE AND FALSE NEGATIVE VALUES OF THE SIX SELECTED ELECTROCARDIOGRAPHIC CRITERIA FOR LEFT ATRIAL ENLARGEMENT

| S.No. | Electrocardiographic Criteria | True Positive | True Negative | False Positive | False Negative |
|---|---|---|---|---|---|
| 1. | P Terminal force in lead V1 more negative than -0.04 mm.s | 33 | 13 | 2 | 12 |
| 2. | Duration of negative phase of p wave in lead V1 > 40 ms | 35 | 11 | 4 | 10 |
| 3. | Depth of negative phase of P wave in lead V1 > 1 mm | 26 | 13 | 2 | 19 |
| 4. | Total P wave duration > 110 ms in any standard lead | 15 | 13 | 2 | 30 |
| 5. | P-mitrale – notched p wave in any standard lead with inter-peak duration > 40 ms | 10 | 15 | 0 | 35 |
| 6. | Macruz index-ratio of the total P wave duration to the P-R segment > 1.6 | 15 | 9 | 6 | 30 |

- Data derived from 60 patients in sinus rhythm.

$$\text{Sensitivity} = \frac{\text{True Positive}}{\text{True Positive + False Negative}}$$

$$\text{Specificity} = \frac{\text{True Negative}}{\text{True Negative + False Positive}}$$

Table III shows the sensitivity and specificity of the six electrocardiographic criteria for left atrial enlargement.

**CRITERION 5 (P mitrale – notched p wave in any standard lead with interpeak duration > 40ms)** had the highest specificity but had extremely low sensitivity.

**CRITERION 2 (duration of the negative phase of p wave in lead V1 more than 40ms)** had the highest sensitivity and also had moderately high specificity.

**CRITERION 1** (PTF in lead V1 more negative than 0.04 ms.s.) had high specificity and moderate sensitivity.

**CRITERION 3** (negative phase of the p wave in lead V1 more than 1mm in depth) AND

**CRITERION 4** (total p wave duration more than 110ms in any standard lead) had comparatively high specificity but low to moderate sensitivity.

**CRITERION 6** (total p wave duration P-R segment duration more than 1.6) had low sensitivity and specificity.

**PREDICTIVE ACCURACY**

In addition to sensitivity and specificity, the performance of a screening test is measured by its “predictive value” which reflects the diagnostic power of the test. The predictive accuracy depends upon sensitivity, specificity and disease prevalence. The “predictive value of a positive test” indicates the probability that a patient with a positive test result has, in fact, the disease in question. The more prevalent a disease is in a given population, the more accurate will be the predictive value of a positive screening test. The predictive value of a positive result falls as the disease prevalence declines.

$$\text{Positive predictive value} = \frac{\text{True Positive}}{\text{True Positive + False Positive}}$$

$$\text{Negative predictive value} = \frac{\text{True Negative}}{\text{False Negative} + \text{True Negative}}$$

Table III shows the predictive values of the six electrocardiographic criteria for left atrial enlargement.

**CRITERION 5** had a 100% positive predictive value.

**CRITERION 1**, 2, 3 & 4 had high positive predictive values (> 85%).

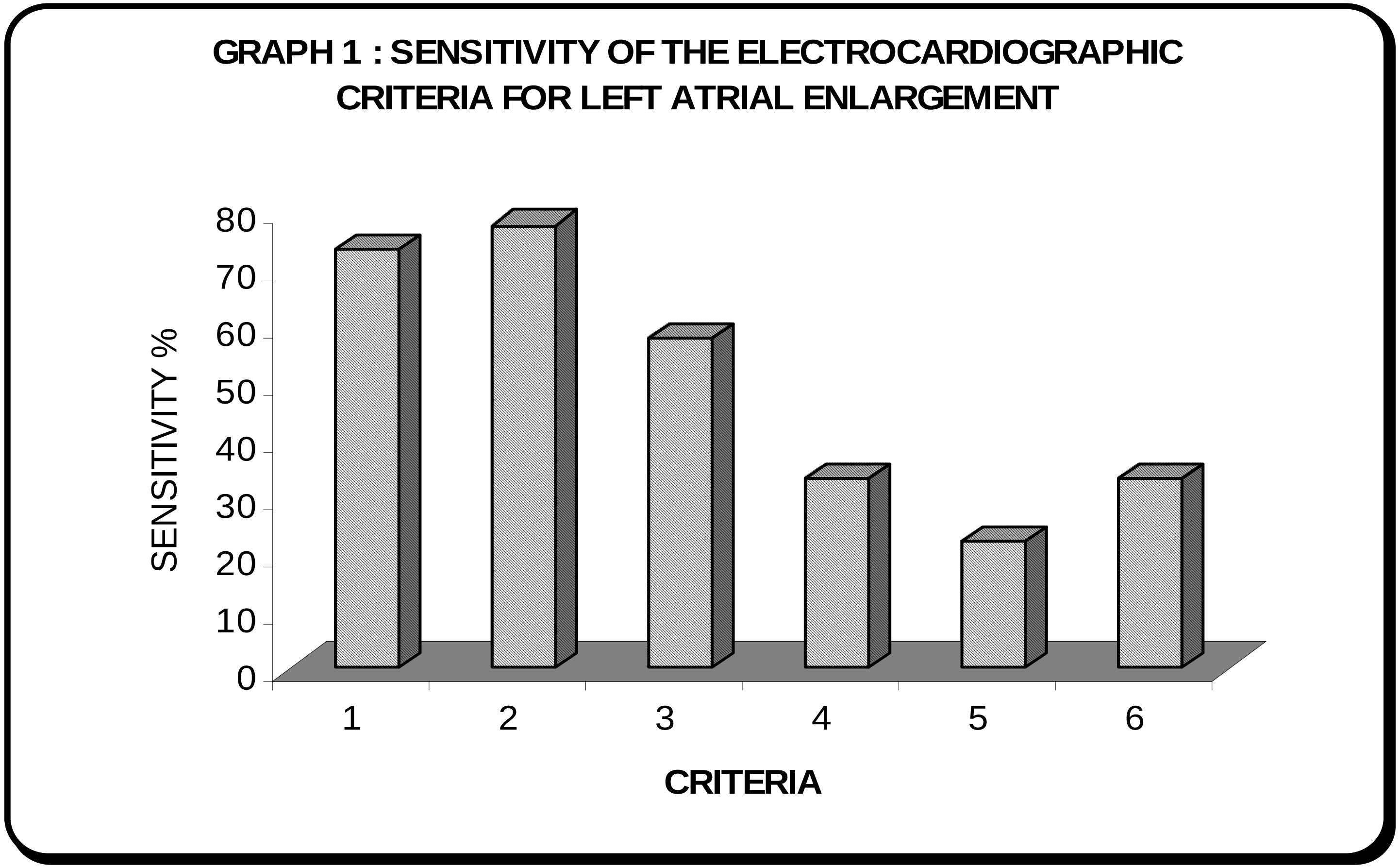
**CRITERION 6** had a low positive predictive value (76.5%).

## TABLE III

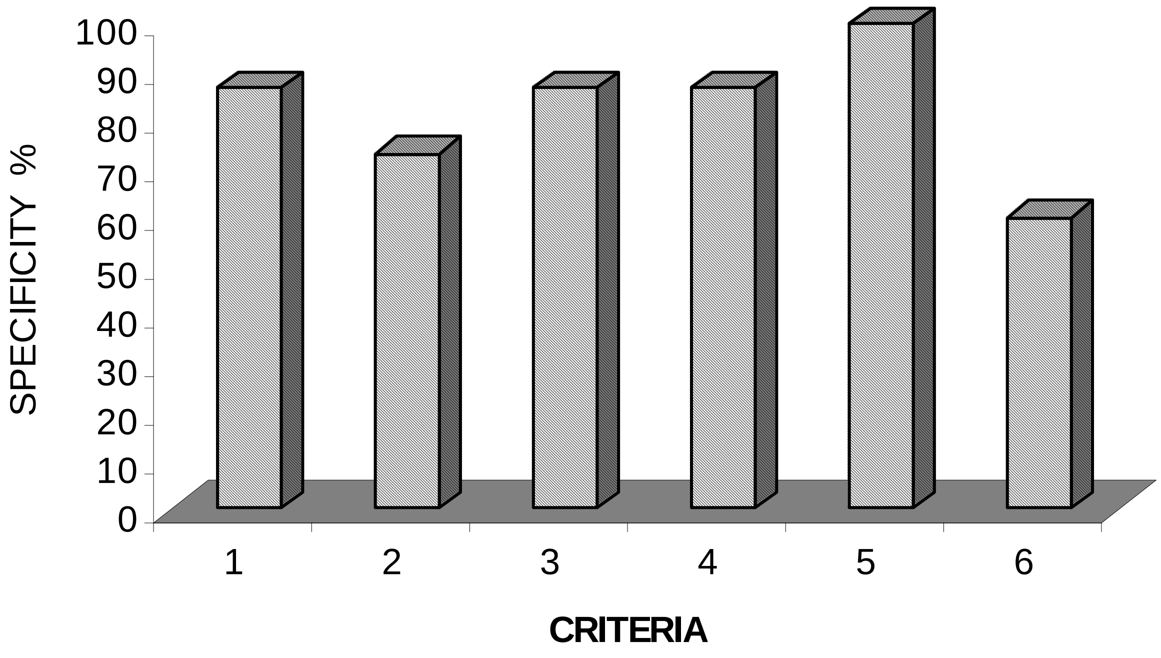
## * SENSITIVITY, SPECIFICITY, POSITIVE AND NEGATIVE PREDICTIVE VALUES OF SIX SELECTED ELECTROCARDIOGRAPHIC CRITERIA FOR LEFT ATRIAL ENLARGEMENT

| S. No. | Electrocardiographic Criteria | Sensitivity (%) | Specificity (%) | Positive Predictive value | Negative Predictive Value |
|---|---|---|---|---|---|
| 1. | P terminal force in lead $V_1$ more negative than -0.04 mm.s | 73.3 | 86.6 | 94 | 52 |
| 2. | Duration of negative phase of P wave in lead $V_1$ > 40 ms | 77.7 | 73.3 | 89.7 | 52.3 |
| 3. | Depth of negative phase of p wave in lead $V_1$ > 1 mm | 57.7 | 86.6 | 92.8 | 40.6 |
| 4. | Total p wave duration > 110 ms in any standard lead | 33.3 | 86.6 | 88.2 | 30.2 |
| 5. | P-mitrale – Notched p wave in any standard lead with inter-peak duration  40 ms | 22.2 | 100 | 100 | 30 |
| 6. | Macruz index-ratio of the total p wave duration to the P-R segment > 1.6 | 33.3 | 60 | 71.4 | 23 |

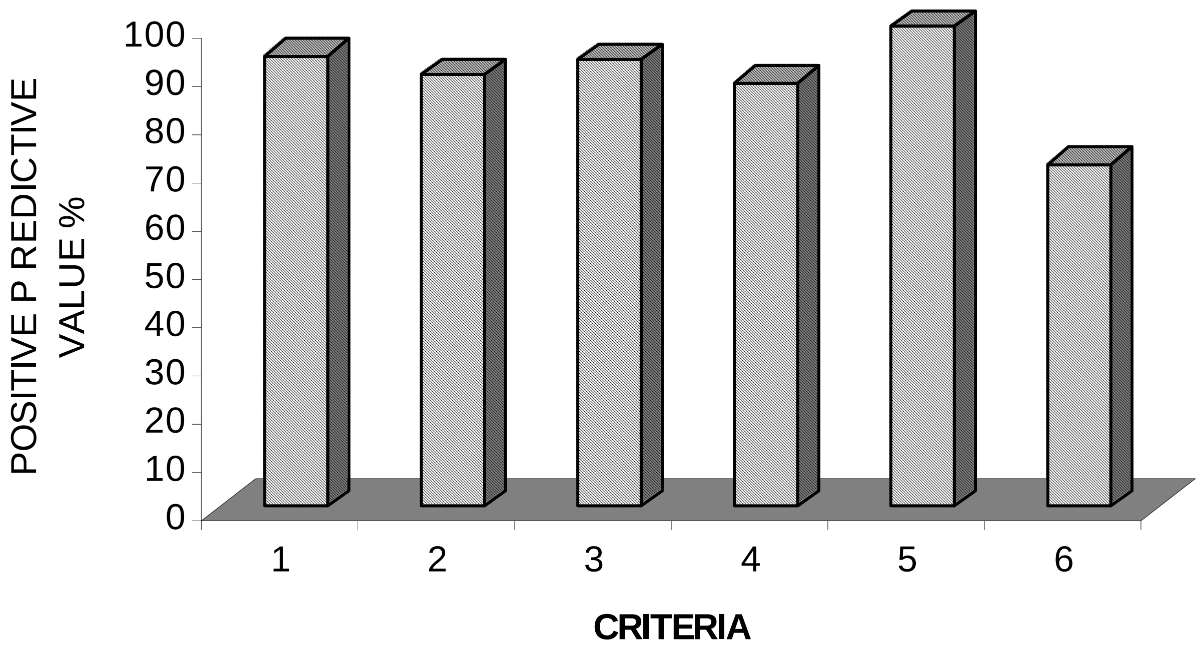
* Data derived from 60 patients in sinus rhythm.


GRAPH 1 : SENSITIVITY OF THE ELECTROCARDIOGRAPHIC CRITERIA FOR LEFT ATRIAL ENLARGEMENT
SENSITIVITY %
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
CRITERIA

**GRAPH 2 : SPECIFICITY OF THE ELECTROCARDIOGRAPHIC CRITERIA FOR LEFT ATRIAL ENLARGEMENT**



**GRAPH 3 : POSITIVE PREDICTIVE VALUE OF THE ELECTRO CARDIOGRAPHIC CRITERIA FOR LEFT ATRIAL ENLARGEMENT**



# DISCUSSION

Although numerous electrocardiographic criteria for left atrial enlargement have been proposed, those described in Table-1 have received much attention in the literature[13,14,15] and are the most frequently used clinically.

Previous studies have shown that these electrocardiographic signs are frequently associated with left atrial enlargement. Recently, however, Josephson and others demonstrated that certain electrocardiographic abnormalities traditionally attributed to left atrical enlargement may occur in patients with left atrial pressure overload or defective atrial conduction[10] or both. Previously it had been established that left atrial thickening with or without left atrial dilatation could produce some of the electrocardiographic signs examined in this study.

These findings suggest that the diagnostic accuracy of previously described electrocardiographic criteria for left atrial enlargement may be more limited than was previously appreciated.

**CRITERION 1 (PTF more negative than -0.04 m sces in lead $V_1$)**

This was originally described by Morris et al. who found it useful in predicting the presence of valvular lesion involving the left side of the heart. It is frequently referred to as the Morris Index.

Its value in the detection of left atrial enlargement has been reasonably well established with sensitivity reported as 67 to 89% and specificity as 83 to 94%. Our results support the assignment of moderate sensitivity (73.3%) and high specificity (86.6%) to this criterion. It had a high positive predictive value of 94%.

The duration and depth of the negative phase of the p wave in lead V1 have frequently been studied as elements of the Morris Index, but have received little attention as individual criteria.

**CRITERION 2 (duration of the negative phase of the p wave in lead $V_1$ more than 40 ms)**

This had the highest sensitivity (77.7%) of any single criterion studied and also possessed moderately high specificity (73.3). It had a positive predictive value of 89.7%. This criterion was the single most effective electrocardiographic criterion for diagnosing left atrial enlargement.

**CRITERION 3 (depth of the negative phase of the p wave in lead $V_1$ > 1mm)**

This is frequently listed as an electrocardiographic marker of left atrial enlargement. This sign has a reported sensitivity of 25% and specificity of 92% in children and in adults the sensitivity is 60% and specificity is 93%. Our results suggest that in adults, this sign has moderate sensitivity (57.7%) but high specificity (86.6%). It had a positive predictive value of 92.8%.

**CRITERION 4 (total p wave duration more than 110 ms in any standard lead)**

Previous studies assessing total p wave duration as a diagnostic marker of left atrial enlargement reported a sensitivity of 4 to 100% and specificity of 62 to 100%,. Correlation with left atrial dimension has been positive in most studies, with correlation co-efficient 0.56 to 0.74. The wide variation in sensitivity and specificity can be explained in the past by differing upper limit of normal among studies (ranging from 105 to 120) and by in the presence of notching in some cases but not in others. Recent studies selected 110 msecs as the upper limit of P wave duration in any standard lead and obtained a sensitivity of 33% and a specificity of 88%. We selected 100 ms as our upper limit. Shorter P wave durations were associated with a marked decrease in specificity and longer duration did not appreciably change sensitivity.

We included p waves with and without notching. Our results suggest that the presence of a p wave duration in any standard lead more than 110 ms, with or without p wave notching, is a relatively insensitive (33.3) but reasonably specific (86.6) electrocardiographic criterion for left atrial enlargement. It has a positive predictive value of 88.2.

Notching of the p wave (p mitrale) has traditionally been attributed to left atrial enlargement presumably reflecting prolonged conduction time within the left atrium.

However small notches are difficult to assess and may occur in persons with normal left atrial size.

**CRITERION 5 (Notched p wave in any standard lead with an inter peak duration more than 40 ms)**

In our study this was an insensitive (22.2) but a highly specific criterion (100%) for left atrial enlargement. This criterion had a 100% positive predictive value. This suggests that the presence of this criterion in the ECG is a definite indication that the patient has left atrial enlargement.

**CRITERION 6 (p wave duration / P – R segment > 1.6)**

This criterion was initially described by Macruz et al. who found the ratio useful in discriminating between cardiac lesions likely to cause left atrial involvement and those likely to cause right atrial abnormalities. The ratio is commonly referred to as the Macruz index.

Previous studies using electrocardiographic left atrial size or angiographic left atrial volume as diagnostic standard have reported a sensitivity of 31 and specificity of 64 for this electrocardiographic criterion.

In this study, criterion 6 had a low sensitivity 33.3 and the lowest specificity (60%) of the six criteria tested. It also had the lowest positive predictive value (71.4). The Macruz index has the same liabilities common to all electrocardiographic criteria for left atrial enlargement, an inability to discriminate among left atrial enlargement, thickening, pressure overload and impaired atrial conduction. In addition, drugs that alter the P – R interval may produce false negative or false positive values.

The absence of haemodynamic and electrophysiologic data in this study is a major limitation in that it precludes categorical assignment of the observed sensitivity and specificity values to left atrial enlargement (dilatation) per se.

However, previous studies showed that many patients with left atrial enlargement also had left atrial pressure overload or defective atrial conduction. Thus, in many patients it may be extremely difficult to sort out the exact origin of the electrocardiographic criteria traditionally attributed to left atrial enlargement.

The use of M – mode echocardiography as a diagnostic standard represents a minor limitation because extreme angulation of the transducer may produce alterations in left atrial diameter. We sought to minimize such artificial measurements by performing echocardiography only from windows in the third or fourth intercostals spaces (left sternal border) and by measuring left atrial size only at the level of the aortic value leaftlets.

# CONCLUSION

- In summary, the single most effective electrocardiographic criterion for left atrial enlargement was duration of the negative phase of the p wave in lead $V_1$ more than 40 ms. It also had a high positive predictive value of 89.7.

- P mitrale (notched p wave in any standard lead with peak to peak duration more than 40 ms) had a very high specificity but extremely low sensitivity. It had a 100% positive predictive value.

- P terminal force more negative than 0.04 sec and depth of the negative phase of the p wave in $V_1$ more than 1 mm had moderate sensitivity but high specificity. They had a high positive predictive value (94 and 92.8 respectively).

- Total P wave duration more than 110 ms had low sensitivity but high specificity. It had a high positive predictive value of 88.2.

- Ratio of the p wave duration to P – R segment duration more than 1.6 (Macruz Index) had a low sensitivity and specificity. It had a low positive predictive value of 71.4.

# PROFORMA

Name : Age : Sex :

Address : Hospital No.

Clinical Diagnosis : ECHO Diagnosis :

**Clinical History**

Chest pain Palpitation

Dyspnoea on exertion Syncope Fever

Embolic episodes Hemoptysis Pedal edema

Cough with sputum H/o. Drug intake :

Rheumatic fever Digoxin

Anti arrhythmic agents

**Physical examination**

Height Weight Body surface area :

Pulse : Peripheral signs of A.R.

B.P. Atrial Fibrillation :

Chest wall deformity

**Cardio vascular system**

Mitral area Pulmonary area

Aortic area Tricuspid area

Other systems : RS.

Abd.

CNS

**INVESTIGATIONS**

E.C.G. Rate Rhythm Axis PR interval

ST –T changes

Chamber enlargement other than LA enlargement

**Criteria studied for LA enlargement**

1. P terminal force in $V_1$.
2. Duration of the negative phase of P wave in lead V1.
3. Depth of the negative phase of P wave in V1.
4. Total P wave duration in any standard lead.
5. Interpeak duration of notched P wave in any standard lead.
6. Total P wave duration / PR segment duration

**ECHO**

1. Left Atrial (end systole) Antero-Posterior dimension

    a. Two dimensional parasternal long axis view.

    b. M-mode Echocardiography

2. Left Atrial volume

$$\frac{4n}{3} \quad \frac{L}{2} \times \frac{D1}{2} \times \frac{D2}{2}$$

L : Superior inferior dimension in apical 4-chamber view

$D_1$ : Antero posterior dimension in parasternal long axis view

$D_2$ : Medial lateral dimension in parasternal short axis view

Chest X-ray

(1) PA view (2) Left lateral view

## Master Chart

| S.No. | Age | Sex | HT | MS | MR | AS | AR | MI | Others | ECG Criteria | | | | | | ECHO | CXR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 1 | 42 | M | + | - | - | - | - | - | - | + | + | - | - | - | - | + | - |
| 2 | 46 | M | + | - | - | - | - | - | - | + | - | - | - | + | + | + | + |
| 3 | 40 | F | + | - | - | - | - | - | - | + | + | - | + | - | - | + | - |
| 4 | 38 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 5 | 44 | F | - | - | - | - | - | + | - | + | + | + | - | - | + | + | + |
| 6 | 42 | F | + | - | - | - | - | - | - | - | + | + | + | - | - | + | - |
| 7 | 36 | M | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 8 | 46 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 9 | 33 | F | - | + | - | - | - | - | - | + | + | - | - | + | + | + | + |
| 10 | 50 | M | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 11 | 41 | F | + | - | - | - | - | - | - | - | - | + | - | - | - | - | - |
| 12 | 45 | M | - | - | - | - | - | + | - | + | - | - | - | + | + | + | + |
| 13 | 39 | F | + | - | - | - | - | - | - | - | + | + | + | - | - | + | - |
| 14 | 45 | M | - | - | - | - | - | + | - | + | + | + | - | - | - | + | + |
| 15 | 52 | F | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 16 | 41 | M | - | - | - | - | - | + | - | - | + | - | + | - | + | + | + |
| 17 | 46 | M | - | - | - | - | - | + | - | + | + | + | - | - | - | + | + |
| 18 | 38 | F | + | - | - | - | - | - | - | + | - | - | - | + | - | + | - |
| 19 | 40 | M | + | - | - | - | - | + | - | + | + | + | - | - | + | + | + |
| 20 | 43 | F | + | - | - | - | - | - | - | + | + | - | + | - | + | - | - |
| 21 | 28 | M | - | + | + | - | - | - | - | + | + | + | - | - | - | + | + |
| 22 | 40 | M | + | - | - | - | - | - | - | - | - | - | - | - | + | - | - |
| 23 | 41 | F | - | - | - | - | - | + | - | - | + | + | + | - | - | + | - |
| 24 | 48 | M | + | - | - | - | - | - | - | + | + | - | - | - | + | + | + |
| 25 | 32 | M | + | + | - | + | - | - | - | + | + | + | - | - | - | + | + |
| 26 | 47 | F | + | - | - | - | - | - | - | - | - | - | + | + | + | + | - |
| 27 | 40 | M | - | - | - | - | - | + | - | + | + | + | - | - | - | + | - |
| 28 | 39 | M | + | - | - | - | - | - | - | - | + | - | - | - | + | - | - |
| 29 | 35 | F | - | + | - | - | - | - | - | + | + | + | - | - | - | + | + |
| 30 | 31 | F | - | + | - | - | - | - | - | - | + | + | - | - | - | + | + |
| 31 | 47 | F | + | - | - | - | - | - | - | + | - | - | + | + | + | + | - |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | 41 | M | + | - | - | - | - | + | - | + | - | - | - | - | + | - | - |
| 33 | 44 | M | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 34 | 50 | F | + | - | - | - | - | - | - | + | + | - | + | - | - | + | - |
| 35 | 34 | M | - | + | + | - | - | - | - | + | + | + | - | - | - | + | - |
| 36 | 40 | F | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 37 | 41 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 38 | 43 | M | - | - | - | - | - | + | - | + | - | - | + | - | + | + | - |
| 39 | 51 | F | + | - | - | - | - | - | - | - | - | - | - | + | + | + | - |
| 40 | 46 | F | + | - | - | - | - | - | - | - | + | - | - | - | + | - | - |
| 41 | 52 | F | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 42 | 42 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 43 | 44 | F | + | - | - | - | - | + | - | + | + | - | + | - | - | + | + |
| 44 | 38 | M | - | - | - | - | - | + | - | + | - | - | - | + | + | + | - |
| 45 | 43 | M | - | - | - | - | - | + | - | - | + | + | + | - | - | + | - |
| 46 | 45 | M | + | - | - | - | - | - | - | - | + | + | - | - | - | + | - |
| 47 | 49 | F | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 48 | 30 | M | - | + | + | - | - | - | - | + | + | + | - | - | - | + | + |
| 49 | 41 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 47 | F | - | - | - | - | - | + | - | + | + | + | - | - | - | + | - |
| 51 | 44 | M | + | - | - | - | - | + | - | - | + | - | + | - | - | + | + |
| 52 | 48 | F | + | - | - | - | - | - | - | - | - | + | + | - | + | - | - |
| 53 | 43 | M | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 54 | 36 | M | - | + | + | + | - | - | - | + | - | - | + | + | + | + | + |
| 55 | 44 | F | - | - | - | - | - | + | - | - | + | + | - | - | - | + | - |
| 56 | 40 | M | - | - | - | - | - | + | - | + | - | - | + | + | + | + | - |
| 57 | 39 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 58 | 47 | F | + | - | - | - | - | - | - | - | + | - | - | - | - | - | - |
| 59 | 37 | F | + | - | - | - | - | - | - | - | + | + | + | - | + | + | - |
| 60 | 40 | M | - | - | - | - | - | + | - | + | + | - | - | - | - | + | - |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |

HT- Hypertension

MR- Mitral Regugitation

AR - Aortic Regugitation

MS - Mitral Stenosis

AS - Aortic Stenosis

MI- Myocardial infarction

CXR - Chest X-ray

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## Master Chart

| S.No. | Age | Sex | HT | MS | MR | AS | AR | MI | Others | ECG Criteria | | | | | | ECHO | CXR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 1 | 42 | M | + | - | - | - | - | - | - | + | + | - | - | - | - | + | - |
| 2 | 46 | M | + | - | - | - | - | - | - | + | - | - | - | + | + | + | + |
| 3 | 40 | F | + | - | - | - | - | - | - | + | + | - | + | - | - | + | - |
| 4 | 38 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 5 | 44 | F | - | - | - | - | - | + | - | + | + | + | - | - | + | + | + |
| 6 | 42 | F | + | - | - | - | - | - | - | - | + | + | + | - | - | + | - |
| 7 | 36 | M | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 8 | 46 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 9 | 33 | F | - | + | - | - | - | - | - | + | + | - | - | + | + | + | + |
| 10 | 50 | M | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 11 | 41 | F | + | - | - | - | - | - | - | - | - | + | - | - | - | - | - |
| 12 | 45 | M | - | - | - | - | - | + | - | + | - | - | - | + | + | + | + |
| 13 | 39 | F | + | - | - | - | - | - | - | - | + | + | + | - | - | + | - |
| 14 | 45 | M | - | - | - | - | - | + | - | + | + | + | - | - | - | + | + |
| 15 | 52 | F | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 16 | 41 | M | - | - | - | - | - | + | - | - | + | - | + | - | + | + | + |
| 17 | 46 | M | - | - | - | - | - | + | - | + | + | + | - | - | - | + | + |
| 18 | 38 | F | + | - | - | - | - | - | - | + | - | - | - | + | - | + | - |
| 19 | 40 | M | + | - | - | - | - | + | - | + | + | + | - | - | + | + | + |
| 20 | 43 | F | + | - | - | - | - | - | - | + | + | - | + | - | + | - | - |
| 21 | 28 | M | - | + | + | - | - | - | - | + | + | + | - | - | - | + | + |
| 22 | 40 | M | + | - | - | - | - | - | - | - | - | - | - | - | + | - | - |
| 23 | 41 | F | - | - | - | - | - | + | - | - | + | + | + | - | - | + | - |
| 24 | 48 | M | + | - | - | - | - | - | - | + | + | - | - | - | + | + | + |
| 25 | 32 | M | + | + | - | + | - | - | - | + | + | + | - | - | - | + | + |
| 26 | 47 | F | + | - | - | - | - | - | - | - | - | - | + | + | + | + | - |
| 27 | 40 | M | - | - | - | - | - | + | - | + | + | + | - | - | - | + | - |
| 28 | 39 | M | + | - | - | - | - | - | - | - | + | - | - | - | + | - | - |
| 29 | 35 | F | - | + | - | - | - | - | - | + | + | + | - | - | - | + | + |
| 30 | 31 | F | - | + | - | - | - | - | - | - | + | + | - | - | - | + | + |
| 31 | 47 | F | + | - | - | - | - | - | - | + | - | - | + | + | + | + | - |
| 32 | 41 | M | + | - | - | - | - | + | - | + | - | - | - | - | + | - | - |
| 33 | 44 | M | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 34 | 50 | F | + | - | - | - | - | - | - | + | + | - | + | - | - | + | - |

| S.No. | Age | Sex | HT | MS | MR | AS | AR | MI | Others | ECG Criteria | | | | | | ECHO | CXR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | 1 | 2 | 3 | 4 | 5 | 6 | | |
| 35 | 34 | M | - | + | + | - | - | - | - | + | + | + | - | - | - | + | - |
| 36 | 40 | F | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 37 | 41 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 38 | 43 | M | - | - | - | - | - | + | - | + | - | - | + | - | + | + | - |
| 39 | 51 | F | + | - | - | - | - | - | - | - | - | - | - | + | + | + | - |
| 40 | 46 | F | + | - | - | - | - | - | - | - | + | - | - | - | + | - | - |
| 41 | 52 | F | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 42 | 42 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 43 | 44 | F | + | - | - | - | - | + | - | + | + | - | + | - | - | + | + |
| 44 | 38 | M | - | - | - | - | - | + | - | + | - | - | - | + | + | + | - |
| 45 | 43 | M | - | - | - | - | - | + | - | - | + | + | + | - | - | + | - |
| 46 | 45 | M | + | - | - | - | - | - | - | - | + | + | - | - | - | + | - |
| 47 | 49 | F | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 48 | 30 | M | - | + | + | - | - | - | - | + | + | + | - | - | - | + | + |
| 49 | 41 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 50 | 47 | F | - | - | - | - | - | + | - | + | + | + | - | - | - | + | - |
| 51 | 44 | M | + | - | - | - | - | + | - | - | + | - | + | - | - | + | + |
| 52 | 48 | F | + | - | - | - | - | - | - | - | - | + | + | - | + | - | - |
| 53 | 43 | M | + | - | - | - | - | - | - | + | + | + | - | - | - | + | - |
| 54 | 36 | M | - | + | + | + | - | - | - | + | - | - | + | + | + | + | + |
| 55 | 44 | F | - | - | - | - | - | + | - | - | + | + | - | - | - | + | - |
| 56 | 40 | M | - | - | - | - | - | + | - | + | - | - | + | + | + | + | - |
| 57 | 39 | M | + | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 58 | 47 | F | + | - | - | - | - | - | - | - | + | - | - | - | - | - | - |
| 59 | 37 | F | + | - | - | - | - | - | - | - | + | + | + | - | + | + | - |
| 60 | 40 | M | - | - | - | - | - | + | - | + | + | - | - | - | - | + | - |

HT- Hypertension

MS - Mitral Stenosis

MR- Mitral Regugitation

AS - Aortic Stenosis

AR - Aortic Regugitation

MI- Myocardial infarction

CXR - Chest X-ray